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ABSTRACT

This report first demonstrates that the concept of accessibility is central to many theories of psychology from quite disparate domains and notes that a distinction of multiple and reflective access also seems to be part of many theories. It then suggests that no theory of intelligence can be complete unless provision is made for the operation of second-order knowledge, that is, knowledge about what we know (reflective access) and flexible use of the routines available to the system (multiple access). The second part of the paper considers the evidence that diagnosis of retarded and learning disabled children's learning problems based on process theories are fundamentally diagnoses of restricted access. It argues that training studies, whether successful or not at inducing transfer, provide rich support for the hypothesis that the slow learning child has peculiar difficulty with the flexible use of knowledge. The final section of the paper discusses the implications of this position for the design of training programs aimed at alleviating the problem of accessibility. The developing technology available for programing transfer of training and the importance of interpersonal settings--particularly mother/child interactions and socratic tutoring--as cognitive support systems for learning are also outlined. (Author/FL)

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Technical Report No. 156

INDUCING FLEXIBLE THINKING: THE PROBLEM OF ACCESS

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Abstract

We begin by illustrating that the concept of accessibility was central to many theories of psychology from quite disparate domains. A distinction similar to Pylyshyn's of multiple and reflective access also seems to be, at least implicitly, part of many theories. Given that accessibility is a core concept in so many current disputes, we suggest that no theory of intelligence can be complete unless provision is made for the operation of second-order knowledge, i.e., knowledge about what we know (reflective access) and flexible use of the routines available to the system (multiple access).

In the second part of the paper we consider the evidence that diagnoses of retarded and learning disabled children's learning problems based on process theories are fundamentally diagnoses of restricted access. Training studies, whether successful or not at inducing transfer, provide rich support for the hypothesis that the slow learning child has peculiar difficulty with the flexible use of knowledge. In the final section we consider the implications of the position for the design of training programs to alleviate the problem of accessibility. Here we address the developing technology we have for programming transfer of training and the importance of interpersonal settings, particularly socratic tutoring, as cognitive support systems for learning.

Inducing Flexible Thinking: The Problem of Access

One of the traditional games played by developmental psychologists is the training study, the aim of which is to induce flexible thinking. The purpose of this enterprise is twofold. First, because our subjects fail to display many of the skills used by more mature learners, it is interesting to see if we can induce these skills by providing instruction. For those who work with impaired thinkers, such as retarded children, the enterprise is much more than interesting; it is essential for remediation. If children cannot, or will not, invent clever learning ploys for themselves, perhaps they can be helped by others more knowledgeable than they.

The training study for the developmental theorist is more than an exercise in applied psychology, however. It serves a purpose very similar to that of the computer models of artificial intelligence or computer simulation. If one's aim is to instill intelligent behavior into a machine, it is necessary to explicitly program what one thinks this is. But to program one must understand. Similarly, for the developmental psychologist who wishes to understand flexible thinking in children, or its absence in special populations, the training is a device for making explicit what we think intelligence is. Sutherland's (1978, p. 116) claim that at present "computer programs are the only tool we have for giving rigorous expression to psychological models, for proving their formal adequacy and consistency, and for investigating their formal limitations" may be true. We would argue, though, that training studies could be used to serve very much the same function.

We have argued elsewhere that central to any thoery of learning are three core concepts: competence, induction, and access (Brown, 1979). By competence we mean the complex issue of the special "belongingness" or compatibility of certain learning activities, a compatibility that is often species-specific with important survival value. Developmentalists tend to address this problem with a consideration of naturalness, and the special value of early learning. By induction we mean the acquisition of new competence and the transition mechanisms accounting for growth. We use access to refer to the ability to access competence, to use flexibly and appropriately the information and skills available to the system. We argue that the training study is an invaluable tool for uncovering problems of competence, induction, and access. As our space is limited, we concentrate in this paper on the topic of accessibility and its centrality both in theories of intelligence and in prescriptions for remediation. The importance of training studies in allowing us to address the problem of access will be discussed in the latter half of the paper.

Accessibility

The concept of accessibility of knowledge is a central one for many theories of intelligence. To illustrate we will describe, briefly, a few quite disparate psychological areas where the question of access is paramount. These examples are not meant to represent an exhaustive overview or even a current position statement. The areas chosen are: (a) cognitive ethology, represented primarily by the work of Paul Rozin (1976); (b) cognitive psychology, particularly the notion of retrievability and transfer-

appropriate processing; (c) artificial intelligence, focusing on the notions of executive functioning; and (d) developmental psychology and the topic of metacognition. In the small space allotted, we can only give a terse synopsis of these areas, but full treatments exist elsewhere and will be referenced when appropriate. The main point of this section is to highlight the notion that some general concept of accessibility is explicitly a central tenet of theories in all four domains, domains that differ widely in their methods but share a concern with the nature of intelligent systems, biological or mechanical.

Cognitive Ethology

The area of cognitive ethology appears to be a blossoming one (Griffin, 1978; Premack & Woodruff, 1978), but for our purposes here, we will concentrate mainly on an imaginative paper by Paul Rozin (1976) concerned with the evolution of intelligence. Rozin considers intelligence as a complex biological system, hierarchically organized, and consisting of a repertoire of adaptive specializations that are the components of subprograms of the system. Throughout the animal world there exist adaptive specializations related to intelligence that originate to satisfy specific problems of survival. Because they evolve as solutions to specific problems, these adaptive specializations are originally tightly wired to a narrow set of situations that called for their evolution. In lower organisms the adaptive specializations remain tightly constrained components of the system. Rozin quotes such widely known examples of prewired intelligence components as the navigational communication ability of bees that is totally restricted to the

defined situation of food foraging (Von Frisch, 1967, but see also Gould, 1978), and the exceptionally accurate map memories of gobiid fish for their own tide pool (Aronson, 1951). This form of intelligence is tightly prewired; although it can sometimes be calibrated by environmental influence, it is pretty much preprogrammed (bird-song development is probably the most elegant illustration of the interplay between prewired components and environmental tuning; Marler, 1970). Rozin's theory is that in the course of evolution, cognitive programs become more accessible to other units of the system and can therefore be used flexibly in a variety of situations. This flexibility is the hallmark of higher intelligence, reaching its zenith at the level of conscious control which affords wide applicability over the full range of mental functioning.

Rozin refers to the tightly wired, limited-access components in the brain as the "cognitive unconscious," and suggests that

> part of the progress in evolution toward more intelligent organisms could then be seen as gaining access to or emancipating the cognitive unconscious. Minimally, a program (adaptive specialization) could be wired into a new system or a few new systems. In the extreme, the program could be brought to the level of consciousness, which might serve the purpose of making it applicable to the full range of behaviors and problems. (Rozin, 1976, pp. 256-257)

Just as part of the progress in evolution toward more intelligent organisms can be seen as gaining access to the cognitive unconscious, so too the progress of development within higher species such as man can be characterized as one of gaining access. Intelligent behavior is first tightly wired to the narrow context in which it was acquired and only later becomes extended

into other domains. Thus, cognitive development is the process of proceeding from the "specific inaccessible" nature of skill, to the "general accessible."

There are two main points to Rozin's accessibility theory. First is the notion of welding (Brown, 1974, 1978; Shif, 1969). Intelligence components can be strictly welded to constrained domains; i.e., skills available in one situation are not readily used in others, even though they are appropriate. Rozin uses this concept to explain the patchy nature of young children's early cognitive ability, which has been described as a composite of skills that are not necessarily covariant. Young children's programs are "not yet usable in all situations, available to consciousness or statable" (Rozin, 1976, p. 262). Development is the process of gradually extending and connecting together the isolated skills with a possible ultimate extension into consciousness.

Closely related is the second notion of awareness or knowledge of the system that one can use. Even if skills are widely applicable rather than tightly welded, they need not necessarily be stable, statable, and conscious. Rozin would like to argue that much of formal education is the process of gaining access to the rule-based components already in the head, i.e., the process of coming to understand explicitly a system already used implicitly. As Rochel Gelman (Note 1) points out, linguistic (and possibly natural number) concepts are acquired very easily, early, and universally, but the ability to talk and the ability to access the structure of the language are not synonymous. The ability to speak does not automatically lead to an awareness of the rules of grammar governing the language.

In his commentary in the special issue of Behavioral and Brain Sciences devoted to consciousness in nonhuman species, Pylyshyn (1978a) makes a similar point when he distinguishes between multiple access and reflective access. Multiple access to the representational components governing chimpanzee behavior is shown by the ability to use knowledge flexibly; i.e., a particular behavior is not delimited to a constrained set of circumstances (the welding argument). Similarly, knowledge is informationally plastic in that it can be "systematically varied to fit a wide range of conditions which have nothing in common other than that they allow the valid inference that, say, a certain state of affairs holds" (Pylyshyn, 1978a, p. 593). Reflective access refers to the ability to "mention as well as use" the components of the system, a situation that would demand that the representational system be available for purposes other than those directly determining the immediately relevant behavior, such as inferring representational states in others, or comparing various desired end states. Reflective access of this kind demands not only that information about a situation be represented in a certain way, but also that the organism has the ability to "represent the representing relation itself"; i.e., not only to represent "the belief B but also the notion of a belief than B" (p. 594).

In his commentary in the same issue, Garner (1978) also makes a distinction similar to the one of multiple and reflective access. Garner suggests that the hallmarks of intelligence are: (a) generative, inventive, and experimental use of knowledge rather than preprogrammed activities (multiple access), and (b) the ability to reflect upon one's own activity (reflective

access). However, Garner makes the point that no organism ever reaches a level of "total consciousness, full awareness, and constant intentionality" for these are "emergent capacities," useful as indices for comparative purposes both within and between species, but never perfectly instantiated even in the mature human. To the extent that organisms come to exhibit more and more of the qualities of reflective and multiple access, we tend to say that they exhibit intelligent behavior.

The twin concepts of flexibility and reflection are important issues in the field of cognitive ethology with wide implications for a general theory of intelligence. Although we have no space to expand on the complexities of the arguments in the area, excellent discussions of the topic appear in the special edition of Behavioral and Brain Sciences (1978) mentioned above.

Cognitive Psychology

In the limited space available, we obviously cannot begin to review the major use of the accessibility notion in mainstream cognitive psychology. Here we would just like to point out that such a concept has traditionally been central to theories of memory and learning. Tulving's classic distinction between availability and accessibility and his thoery of encoding specificity have been incorporated within the levels-of-processing theories to explain a great deal of the recent process-oriented literature on adult memory (Tulving, 1978). In short, we have a great deal of evidence that: (a) people frequently store information that they are unable to retrieve when needed; (b) the presentation of appropriate retrieval environments leads to access to material previously "forgotten"; (c) different testing

situations provide different retrieval environments, and therefore, assessments of the availability of knowledge vary as a function of retrieval support in the testing context; and (d) the compatibility between encoding and retrieval contexts is vitally important as a determinant of the ability to access previously stored materials (Bransford, 1979; Norman & Bobrow, 1979; Tulving, 1978). All these arguments concern the optimal conditions for making information in memory accessible when needed; it is not sufficient to simply store information, for unless it can be activated when needed it is of little use.

There is a great deal of data suggesting that the memory system can be quite inflexible unless careful planning for retrieval is undertaken, a notion that is reflected in Bransford's (1979) theory of transfer-appropriate processing, which also stresses the compatibility between the learning activity and the goal of that activity or the purposes to which the information must be applied. Learning activities are purposive and goal directed, and an appropriate learning situation must be one that is compatible with the desired end-state. One cannot, therefore, discuss appropriate learning activities unless one considers the question of "appropriate for what end?" A form of knowledge that permits optimal rote memory is not necessarily appropriate for understanding a novel input or applying a novel concept (Nitsch, 1977). Again the guiding principle of these arguments is one of accessibility--how to ensure, by preplanning, the flexible use of knowledge available to the system.

The second major concept in mainstream cognitive psychology that is pertinent to our argument is the controversial notion of executives, head-demons, interpreters, homunculi, central processors, or "the single, conscious high-level mechanism that guides the conceptual processing" (Bobrow & Norman, 1975; see also Norman & Bobrow, 1979). The development of these concepts was inspired by the emergent field of artificial intelligence, and, therefore, we will address them under that heading.

Artificial Intelligence

Researchers concerned with the creation of intelligent behavior in machines are forced to make explicit exactly what they think constitutes intelligence, hence the fascinating controversies surrounding the problem of how intelligent machines are now (or could be in the future). The issues raised by these controversies are central to our conception of mind (Bobrow & Collins, 1975; Flores & Winograd, Note 2; Pylyshyn and following commentaries, 1978a,b). We will restrict ourselves to the problems of accessibility and knowledge of knowledge.

Moore and Newell (1974, pp. 204-205) made a succinct statement of the welding problem when they defined the essence of machine understanding in reference to two criteria. First, "S understands K if S uses K whenever appropriate"; second, this "understanding can be partial, both in extent (the class of appropriate situations in which the knowledge is used) and in immediacy (the time it takes before understanding can be exhibited)." We judge as intelligent the flexible, appropriate, and rapid application of the knowledge available to the system. This distinction is between

knowledge and the understanding of that knowledge, where understanding is defined in terms of appropriate use or ready access.

A more stringent criterion of understanding is that knowledge be available to consciousness and perhaps be statable (Garner, 1978; Rozin, 1976). An intelligent system must have the capability to be aware of itself. This second-order knowledge, knowing about what we know and what we can know, is a thorny problem for the designers of machine intelligence (Winograd, 1975). Ignoring the complexities, most theories of machine intelligence assume some form of executive bookkeeping, a system that plans and guides cognitive activities, keeps track of the activities of subordinate processes, determines their success, failure, or appropriateness, generates new subprocesses, and allocates resources. This central system must in some sense be said to have "awareness" of its own processes and of the information sent to it by lower order mechanisms. In other words, the intelligent machine must have access to and control of its own attempts to be intelligent. "Man not only has consciousness, but he knows that he has it" (Katz, 1939). Of issue to cognitive ethologists is the question, Do animals know? Of issue to those in the field of artificial intelligence is the question, Can machines know? Of issue to those who would build a theory of intelligence is the centrality of the concepts of accessibility.

Developmental Psychology: Metacognition

One of the most influential trends in developmental cognitive psychology is the growing interest in problems subsumed under the heading metacognition (Brown, 1978; Flavell, Note 3). Metacognition has always been a controversial

term referring to an imprecise concept with fuzzy boundaries, and many of the controversies reflect some of the persistent problems of psychology, e.g., the nature of consciousness, intentionality, cognitive homunculi, and epistemic mediation. The area therefore has an affinity with cognitive ethology and artificial intelligence in confronting the problems of second-order knowledge.

The term metacognition has been used in the developmental area to refer to two somewhat separate phenomena, and we would like to make this separation explicit here. Flavell (Note 3) defined metacognition as "knowledge that takes as its object or regulates any aspect of any cognitive endeavor" (p. 4). Two (not necessarily independent) clusters of activities are included in that statement--knowledge about cognition and regulation of cognition.

The first cluster is roughly concerned with a person's knowledge about his own cognitive resources and the compatibility between himself as a learner and the learning situation. Prototypical of this category are questionnaire studies and confrontation experiments, the main purpose of which is to find out how much children know about certain pertinent features of thinking, including themselves as thinkers. The focus is on measuring the relatively stable information that the learner has concerning "subject, task, and strategy variables" involved in any cognitive task (Flavell, Note 3). This information is stable in that one would expect a child who knows pertinent facts about the total learning situation (e.g., that organized material is easier to learn than disorganized material, that in normal circumstances his immediate span is unlikely to exceed seven items)--to continue to know

these facts if interrogated appropriately. These are stable forms of knowledge which develop with age and experience but are information sources available to the learner whenever needed. This type of information is also statable, by definition, as the measure of awareness used is almost always verbal justification and explanation (Brown, 1978).

The second cluster of activities are those concerned primarily with self-regulatory mechanisms during an ongoing attempt to learn or solve problems. These indices of metacognition, such as checking, planning, monitoring, testing, revising, and evaluating (Brown, 1978), are not stable features in the sense that the degree to which they will be available to the system depends upon other aspects of the learning situation. These "executive functions" are resource demanding and are most likely to occur when the subprocesses that they control are relatively familiar or automatized. Stated in information-processing terms, the executive competes for workspace with the subroutines it controls, and the degree to which these monitoring activities will be engaged in depends very critically on the nature of the task, the expertise of the learner, and the resultant pressures on central processing capacity. Thus, these activities are not necessarily stable, because they will appear or disappear depending on the familiarity and difficulty of the problem, the child's motivation, etc. They are also not necessarily statable as a great deal of selecting, monitoring, inferring, etc. must go on at a level below conscious awareness.

The issues of metacognition have been examined at length, some might say ad nauseum, elsewhere. For our purposes here, we emphasize that once

again the underlying problems are those of appropriate use of, or access to, knowledge. This emphasis is illustrated in the attempts to provide a metacognitive explanation of transfer of training (Brown & Campione, 1978) and in the extensive research devoted to uncovering the child's awareness of the knowledge available to the system (Flavell, Note 3).

Given the pervasiveness of the concept of accessibility, we are convinced that no theory of intelligence can be complete without ceding this concept a central place, and no serious discussion of what intelligent behavior is could occur without mention of the difficult issues elicited by the family of ideas implied by the term, i.e., awareness, intentionality, consciousness, automatic vs. deliberate processing, etc. We argue that multiple access and reflective access to knowledge are the hallmarks of intelligent activity. Elsewhere we have detailed a theory of intelligence in terms of executive control processes (Brown, 1974, 1978; Brown & Campione, 1978; Brown & French, 1979; Campione & Brown, 1978), as indeed have others (Butterfield, Note 4), and we will not repeat the argument here.

Implications for a Theory of Retardation

The recent increase in both the extent and quality of theoretical and empirical work concerned with learning in retarded individuals affords greater security to those who would try to identify the locus (loci) and magnitude of academic deficits in the intellecutally impaired; at least this holds true for the use of strategies to solve common memory and problem-solving tasks. Within this domain we are confident that multiple and reflective access to available knowledge present particular difficulty.

Specifically, lack of multiple access to the fruits of learning is reported so often that "welding" has been described as a characteristic feature of the learning of retarded children by both Soviet and American researchers (Brown & French, 1979), not to mention parents and teachers.

Our current knowledge about the performance of retarded children on common learning and memory problems can be summarized as follows. These children perform poorly on a variety of problems that demand the use and control of strategies for adequate solution. With intensive, well-designed training, their performance improves dramatically, particularly when the training concentrates on both inculcating the desired strategies and providing detailed instructions concerning self-regulation. Retarded children experience difficulty primarily in transferring the results of any training to new situations, and this diagnostic transfer failure is particularly likely to occur if explicit instruction in self-regulatory mechanisms is not provided. When training does include instruction in both the use and control of the desired skill(s), training attempts are successful (Brown, Campione, & Barclay, 1979). Similarly, another technique that is showing early promise is training in multiple contexts (Belmont, Butterfield, & Borkowski, 1979), a procedure that makes explicit the fact that the trained behavior is trans-situationally applicable.

Recent successes at inculcating transfer have been taken as evidence to weaken the claim that generalization of the effects of instruction is a major, if not the major, drawback to academic efficiency in the mildly retarded. We disagree and suggest that, transfer successes notwithstanding, the training

literature provides a rich illustration of the centrality of the access problem for such children. The limited number of successful studies to date rest on extensive, explicit instruction in how to approach the problem, based on detailed task analyses that are provided by the experimenter (no invention on the part of the learner is required). In addition, explicit, detailed instruction in the multiple uses and control of the trained skill may be required. We would argue that in order to find significant transfer effects in retarded learners, one must make explicit what average children can induce.

A traditional definition in intelligence is the speed and efficiency of learning (Thorndike, 1926), and one must consider the efficiency of training attempts in this light. How readily do the subjects respond to training? And, how efficiently do they transfer the information, where efficiency is measured in terms of Moore and Newell's (1974) criteria of extent (broad generalizations) and immediacy (without additional prompting and training)? Resnick and Glaser (1976) also argue that intelligence is the ability to learn in the absence of direct and complete instruction, and Brown and French (1979) identify this as the crux of Vygotsky's (1978) theory of proximal distance or potential development.

Rejecting phylogenetic discontiguity theories, Garner (1978) uses similar criteria for comparisons between species.

> Just where we ultimately draw the line between human and infrahuman capacities will depend on the <u>ease with which</u>, and the <u>extent to which</u>, other animals acquire the kind of cognitive, linguistic and symbolic behavior which human beings universally acquire. (p. 572)

He argues further that these are suitable criteria for those who would make ontogenetic comparisons. Flexible, inventive, and playful behaviors in the absence of complete programming are the essence of intelligence.

> Conversely, to the extent that behaviors (1) appear only when elicited by strong training models, (2) recur in virtually identical form over many occasions, (3) display little experimental playfulness, (4) exhibit restricted coupling to a single symbolic system, or (5) fail ever to be used to refer in 'meta' fashion to one's own activities, we are inclined to minimize their significance [as indices of intelligent behavior.] (Garner, 1978, p. 572)

To the extent that the above definition of restricted coupling, welding, etc. is a reliable description of retarded children's learning (i.e., they tend to employ strategies only if someone else invents them and programs their appropriate use), they are by definition displaying evidence of limited intellectual capacity. To date, training studies, whether successful or not, support the original diagnosis of a fundamental problem of accessibility underlying the pervasive learning problems of retarded children.

Implication for a Theory of Remediation

A thorough understanding of the nature of retarded children's problem-solving activities should enable us to design programs that will alleviate their characteristic difficulties. If we accept the notion that restricted access to acquired knowledge is an adequate diagnosis, how then would this influence our design of training programs? Also, what kind of cognitive support systems can we offer the immature as a prop for their learning

activities? In this section we concentrate on two main technologies designed to overcome the problem of welding or multiple access, and to provide a scaffolding for the emergence of executive control on the part of the child. First, we deal briefly with the design of adequate training programs in terms of task analysis and programming self-regulation and generalization. Second, we deal with the interpersonal nature of problem solving and the importance of social settings as cognitive support systems.

Programming Transfer

Detailed prescriptions concerning ideal training programs to overcome the problem of multiple access exist elsewhere (Brown, 1974, 1978; Brown & Campione, 1978; Campione & Brown, 1978; Meichenbaum, 1977; Butterfield, Note 4). We include here an overview account of the major steps, an account that is adapted from a prior paper (Brown & Campione, 1978) where we deal with the topic at greater length. In that paper we identify seven features that a training procedure must include if generalization of the effects of training is the desired result: (a) careful selection of the cognitive skill to be measured; (b) sensitivity to the actual beginning competence of the learner; (c) stringent analysis of the requirements of the training and transfer tasks so that transfer failures may be interpreted properly; (d) training in multiple settings to alleviate the problem of welding; (e) direct feedback concerning the effectiveness of the trained skill; (f) direct instruction concerning the generalization of the trained skills; and (g) direct instruction in self-management routines.

A reliable method for producing a successful training package is to base its design on adequate task, situation, and subject analyses. After inducing adequate performance, the question then becomes whether or not the instruction is durable. That is, when minor changes in the surface structure are made, will the effects of training persist over time without the use of intrusive aids? Successful training must result in appropriate generalization; the trained strategies should transfer to tasks where their use would be beneficial, but not to situations where their use would be inappropriate. Generalization involves more than just the use of a trained behavior; it also involves the ability to discriminate between appropriate and inappropriate conditions for transfer (Brown, 1978; Campione & Brown, 1978).

The simplest form of transfer failure occurs when a child does not even maintain the newly trained behavior unless specifically prompted to do so (Brown, 1978; Brown et al., 1979). In this case, one might ask if the child realized the training actually improved his performance. To anticipate this problem, the design should incorporate explicit feedback concerning the new behavior's effectiveness.

Given that the aim of training is to achieve not only maintenance but also generalization, a second major type of transfer failure is related to the problem of welding, or lack of multiple access. The numberous examples of such welding in the literature suggest that direct attempts to overcome the problem should be initiated. Training in multiple settings appears to be one answer. Instructing the learner in the use of a single strategy in

a variety of appropriate settings should reduce the tendency for strict situationally specific learning to occur (Belmont et al., 1979; Brown, 1974, 1978; Campione & Brown, 1974).

Very young children in a training study often are not cognizant of the relationship between separate phases of the experiment (Bullock & Gelman, 1977; Campione, 1973), and consequently, it is understandable that the strategy acquired in stage one is not readily used in stage two. Therefore, if the goal of the training is to attain flexible generalization, it would be reasonable to incorporate into the training package direct instructions concerning generalization. For example, a child could be told that the trained behavior could be used in a variety of similar tasks, but that it also could be detrimental if the task was inappropriate. One would then go on to provide examples of both appropriate and inappropriate tasks; the utility of the strategy would be demonstrated for the appropriate ones, as well as an explanation of the reason for not using the strategy on the inappropriate tasks. Finally, the child's understanding could be tested by giving him/her a selection of both types of tasks and asking him/her to indicate where the strategy should be employed.

The choice of both the training and transfer tasks becomes crucial in this type of study; the tasks must be related in such a way that efficient users of the particular cognitive skill automatically adopt it for use on both occasions. In other words, the tasks must evoke the same underlying cognitive process, but must be distinct enough so that they are a proper test of the ability to generalize. Many of the "successful" training

studies have employed transfer tasks that vary so little from the training vehicle that it could be argued that they have merely achieved maintenance rather than generalization. The investigator must justify the distinction between maintenance and generalization on at least practical, and preferably theoretical, grounds.

Also of importance is the need on the part of the investigator to distinguish between different potential causes of transfer failures. When a transfer failure occurs, the investigator's natural tendency is to conclude that the trainee could not see the relation of the trained behavior to the new task and act upon it. However, an alternative explanation may be that the child was unable to execute some other component of the transfer task, thus making success impossible. In an early series of studies designed to identify transfer mechanisms in a discrimination learning paradigm (Campione & Brown, 1974), a number of possible reasons for failing to observe transfer were discussed. One reason, which was termed the interaction of components hypothesis, was based on the supposition that a child might in fact be able to generalize on a particular transfer task, but be incapable of demonstrating that skill, due to an inability to deal with another component of the task. For example, if the child could not name or label the stimuli, any attempt to generalize a trained rehearsal strategy to a new task would be thwarted. Thus, an experimenter must be cautious when interpreting transfer failures. It may be that by providing additional training in the extra demands of the new task, the whole complexion of the results would change.

Our final prescription for achieving both adequate initial learning and subsequent transfer is to design self-management techniques of the kind favored by cognitive behavior modifiers (Meichenbaum, 1977) and developmental psychologists interested in general metacognitive skills (Brown, 1978). The types of general problem solving skills we are particularly interested in are the tendencies to stop and think before attempting a problem, asking questions of oneself and others to determine if one recognizes the problem, checking solutions, and monitoring attempts to learn to see if they are working or are worth the effort (Brown, 1978). We have some preliminary evidence that training such general skills will be effective in producing transfer; and our major success to date in programming significant transfer came when we added a simple self-testing element (estimating one's own recall-readiness) to the training package (Brown et al., 1979).

We are currently examining the generality of the effects of teaching children to self-interrogate when faced with a certain class of problems (instructions, math problems, a laboratory task, etc.). The type of self-interrogation which we think might work is to provide the child with a routine set of questions to ask him/herself before proceeding, e.g.: (a) Stop and think! (b) Do I know what to do (i.e., understand the instructions, both explicit and implicit)? (c) Is there anything more I need to know before I can begin? And (d) is there anything I already know that will help me (i.e., is this problem in any way like one I have done before)? It is with self-instructional routines such as these that those engaged in

behavior modification training and classroom management have achieved their major success in programming generalized improvement (Meichenbaum, 1977).

Other-Regulation to Self-Regulation

The most available cognitive support system for the developing child is that provided by interaction with significant others, initially the parents, and then teachers and peers. There are some who claim that the primacy of social support for intellectual activity is true also of adults (Cole, Hood, & McDermott, Note 5). Studies of mother-child dyads solving problems provide a rich picture of the interactive nature of learning (Kaye, 1970; Wood, Bruner, & Ross, 1976; Wood & Middleton, 1975; Wertsch, Note 6). It is not simply the case that the mother models and the child imitates. The interactions are far more elaborately orchestrated. The mother appears to tailor her intervention to the child's "region of sensitivity to instruction" (Wood & Middleton, 1975), or level of potential development (Brown & French, 1979; Vygotsky, 1978), i.e., just one step beyond the child's current operational level. If, following such help, the child succeeds, the mother is less explicit on the next attempt. If the child fails, she repeats the help or becomes more explicit. The choreography of the dynamic interaction reveals a great deal of interpersonal sensitivity on the part of both mother and child. The successful mother extracts from the child not only optimal performance but, more importantly, she elicits autonomy by ceding executive control to the child.

Wertsch's (1978) study of mother-child dyads suggests just such a gradual progression from other-regulation (mother) to self-regulation on the part of the child. The assumption is that through such interaction the child develops self-regulation by gradually assuming the regulatory role first adopted by the mother. Initially, the mother directs, but her instructions do not guide the child's behavior. An intermediate stage then follows where the mother successfully adopts the role of executive, guiding and regulating the problem-solving activity of her child. Finally, the mother cedes control to the child and functions primarily as a sympathetic audience. These mother-child interactions are prototypical of other ideal interpersonal learning situations, such as socratic teaching; a novice is led to mastery and autonomy by the sensitive intervention of another who is more skillful.

Parents are by no means the only social agent to perform the function of fostering self-regulation. Teachers, tutors, and master craftsmen in traditional apprenticeship situations all function ideally as promoters of self-regulation by nurturing the emergence of personal planning as they gradually relinquish their own direction. Effective teachers are those who engage in continual prompts to get children to plan and monitor their own activities. In a recent study of effective teachers, Schallert and Kleiman (1979) described four general strategies used to facilitate children's learning: (a) tailoring the message to the child's existing level of understanding; (b) activating relevant schemata (prior knowledge); (c) focusing attention on relevant and important facts; and (d) monitoring comprehension

by means of such socratic ploys as invidious generalizations, counter-examples, and reality testing (Brown, 1978; Collins, 1977). In short, the expert teacher provides much of the executive control for the child, executive functions that the child must internalize (Vygotsky, 1978) as part of his own problem-solving activities if he is to develop effective problem-solving strategies.

Just as the tutoring situation is one form of social support system for learning, groups may also relieve some of the personal responsibility of control from the individual members. Indeed, in their classic review of group problem-solving, Kelley and Thibaut (1954) put forward an internalization theory very similar to Vygotsky's; and a social psychologist's description of group functions sounds very like a description of executive control:

> Qualitatively group discussions seemed to be adequately characterized by the traditional analyses of individual thinking, e.g., stated by Dewey as: 1) motivation by some felt difficulty, 2) analysis and diagnosis, 3) suggestion of possible solution or hypothesis, and perhaps 4) an experimental trying out, before 5) accepting or rejecting the suggestion. (Dashiell, 1935, p. 1131)

Most of these activities seem to be variants of the basic transsituational skills of predicting, checking, monitoring, and reality testing (Brown, 1978). But in spite of the evidence that the basic elements of self-regulation become part of a child's repertoire via the process of internalizing that which was originally social (Vygotsky, 1978), most studies concerned with training self-regulation have not used social interactions as a vehicle for training, and most studies of metacognition have been concerned

with self-regulation during individual problem solving. The child is typically told to check, monitor, or self-test by an experimenter who invents the program for him (Meichenbaum, 1977); he has no chance to take part in a dynamic social interaction where experts (adults or peers) display executive functions in the normal course of problem solving. The natural situation of the expert unobtrusively adopting, the gradually relinquishing, control as the novice gains mastery seems to be an ideal training model to follow if the aim is to encourage autonomy.

The management of such dynamic interplay is by no means simple. A crucial problem facing the tutor is deciding at what level to intervene. In effect, the tutor must engage in continuous diagnosis of the present state of learning so that intervention can be tailored to the child's current needs. In peer problem solving, the participants must divide up the responsibility of performing subparts and accepting control. In the classroom, the problem is even more difficult, as ideally the teacher should be sensitive to the level of understanding of several children at once. The basic aim of all these activities is to train the child to think dialectically, in the sense of the socratic teaching method. In the socratic method, the teacher constantly questions the student's basic assumptions and premises, plays the devil's advocate, and probes weak areas, using such techniques as invidious generalizations and counterexamples (Collins, 1977). The desired end-product is that the student will come to perform the teacher's functions for him/herself via self-interrogation and self-regulation. We realize the difficulty of mounting training programs based on naturally occurring tutoring

situations. But in view of the pervasiveness of the retarded child's problems with multiple and reflective access, intensive training in the laboratory that aims at mimicking the cognitive support systems believed to be responsible for the natural development of self-regulation seems to be a worthwhile endeavor.

Summary

We began by demonstrating that the concept of accessibility was central to many theories of psychology from quite disparate domains. A distinction, similar to Pylyshyn's, between multiple and reflective access also seems to be, at least implicitly, part of many theories. Given that accessibility is a core concept in so many current disputes, we suggest that no theory of intelligence can be complete unless provision is made for the operation of second-order knowledge, i.e., knowledge about what we know (reflective access) and flexible use of the routines available to the system (multiple access).

In the second part of the paper, we considered the evidence that diagnosis of retarded and learning disabled children's learning problems based on process theories are fundamentally diagnoses of restricted access. Training studies, whether successful or not at inducing transfer, provide rich support for the hypothesis that the slow learning child has peculiar difficulty with the flexible use of knowledge.

In the final section, the implications of this position for the design of training programs aimed at alleviating the problem of accessibility were considered. Here we outlined the developing technology we have for programming

transfer of training and the importance of interpersonal settings, particularly mother-child interactions and socratic tutoring, as cognitive support systems for learning.

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